Surveying and Servoing with CoTS components as Canonical Tasks in Future Farms

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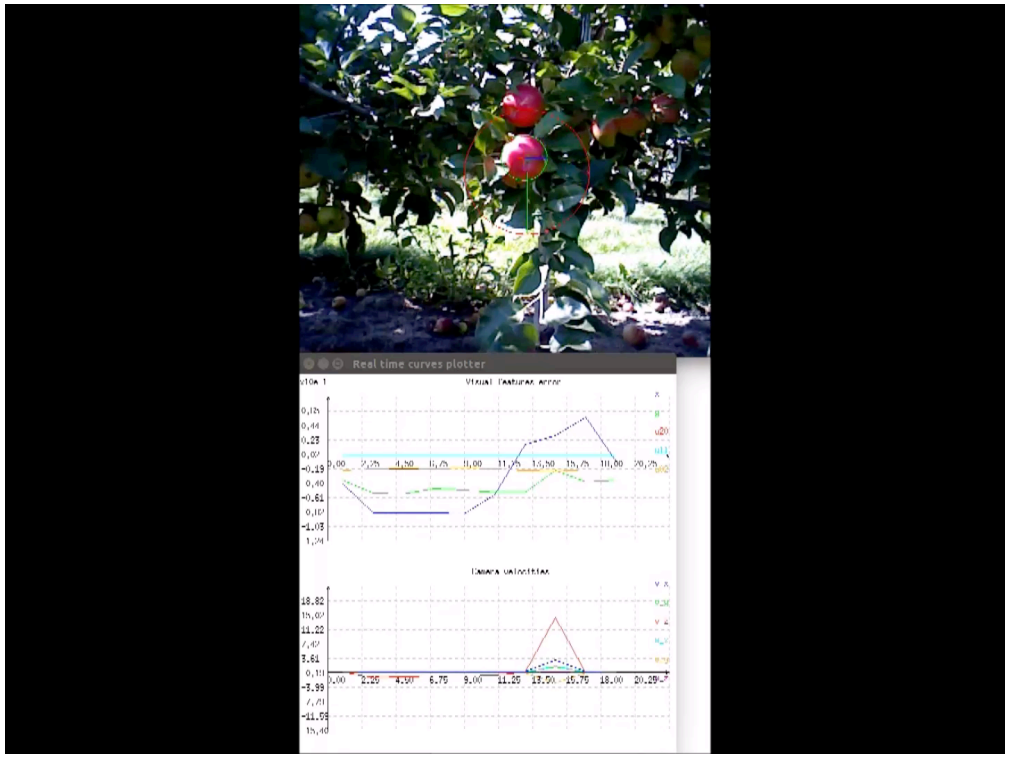
Surveying as a Canonical Task

Yield estimation, disease detection,
fertilizer application for precision agriculture

Servoing as a Canonical Task

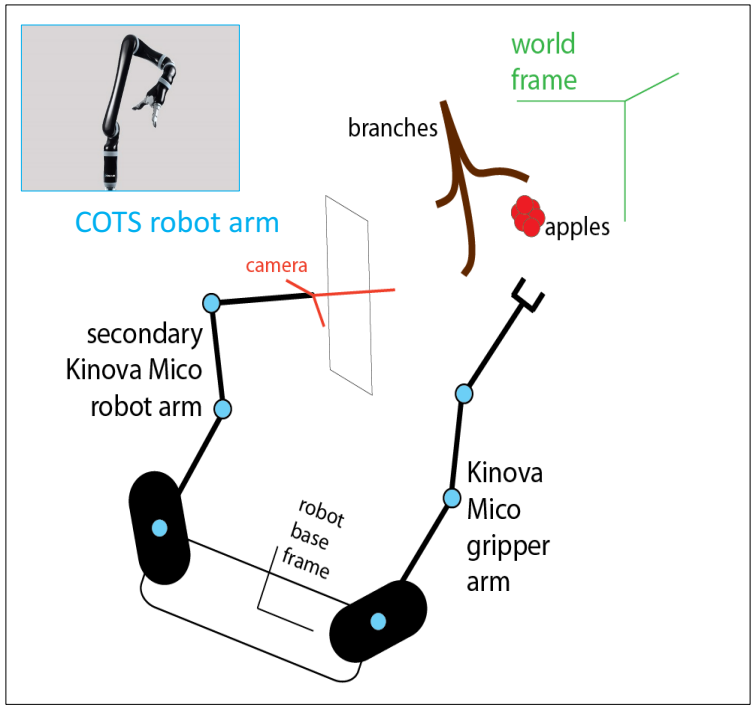


Close-up inspection, pruning, picking, pesticide application, phenotyping

Project Focus

View Planning for Surveying

Servoing



without any specialized hardware!

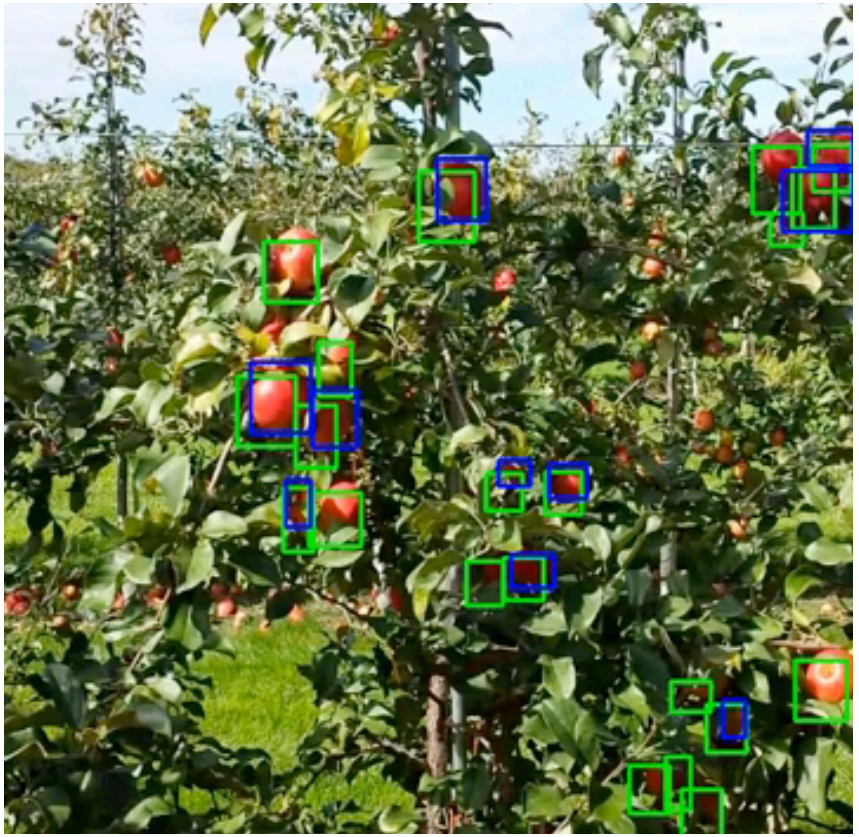
Geometric models and matching view planning algorithms in known or unknown environments

GRIPPER robot arm and **CAMERA** robot arm working together

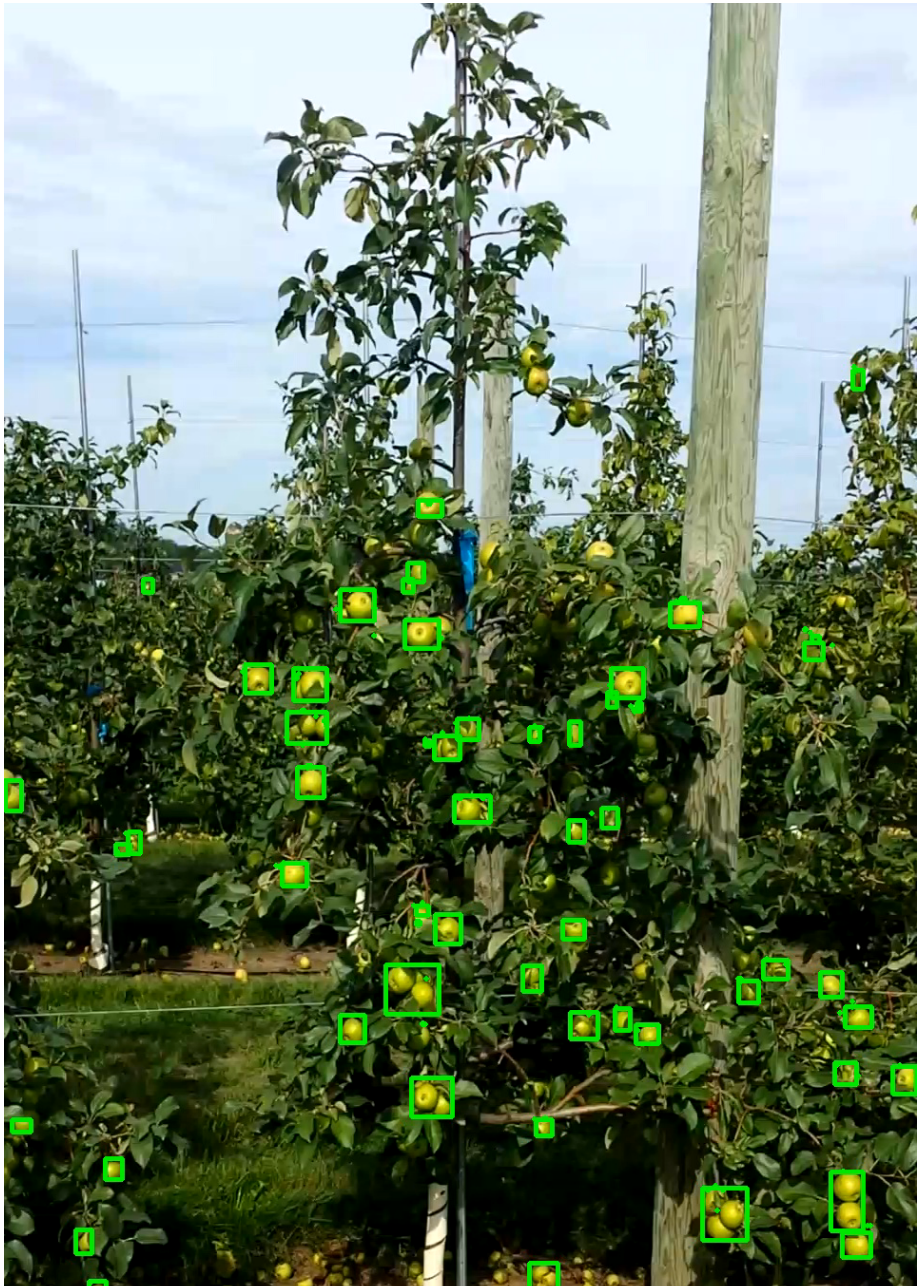
Since then..

Autonomous Navigation

Yield Mapping



Green Fruit Detection

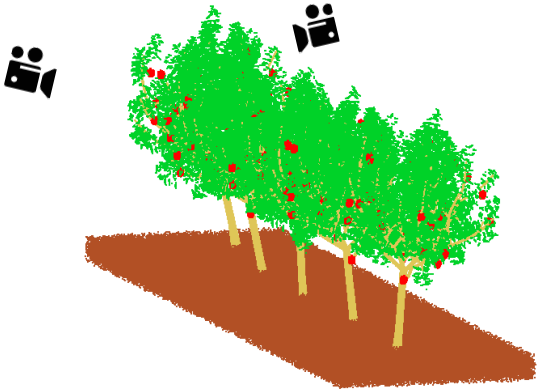


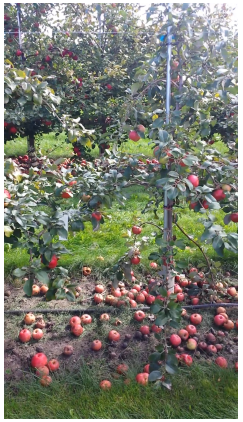
Deep Learning for Fruit Counting - Results

Yield estimation accuracy: 95-97%

3D Reconstruction for Counting

Footage from one side of the row





Footage from opposite side of the row

One side reconstruction

Opposite side reconstruction

Next, we scan the other side and merge these two reconstructions.

Most Recent Results – on arXiv

- **Semantic Mapping for Orchard Environments by Merging Two-Sides Reconstructions of Tree Rows,**
  Dong, Roy, Isler
- **A Comparative Study of Fruit Detection and Counting Methods for Yield Mapping in Apple Orchards**
  Hani, Roy, Isler
- Also: **Robotic surveying of fruit plants**
  Patent number: 9922261
  Date of Patent: March 20, 2018


FARM VISION
ABOUT
TECHNOLOGY
CONTACT
PRECISION MAPPING
FOR FRUIT PRODUCTION

Along the way

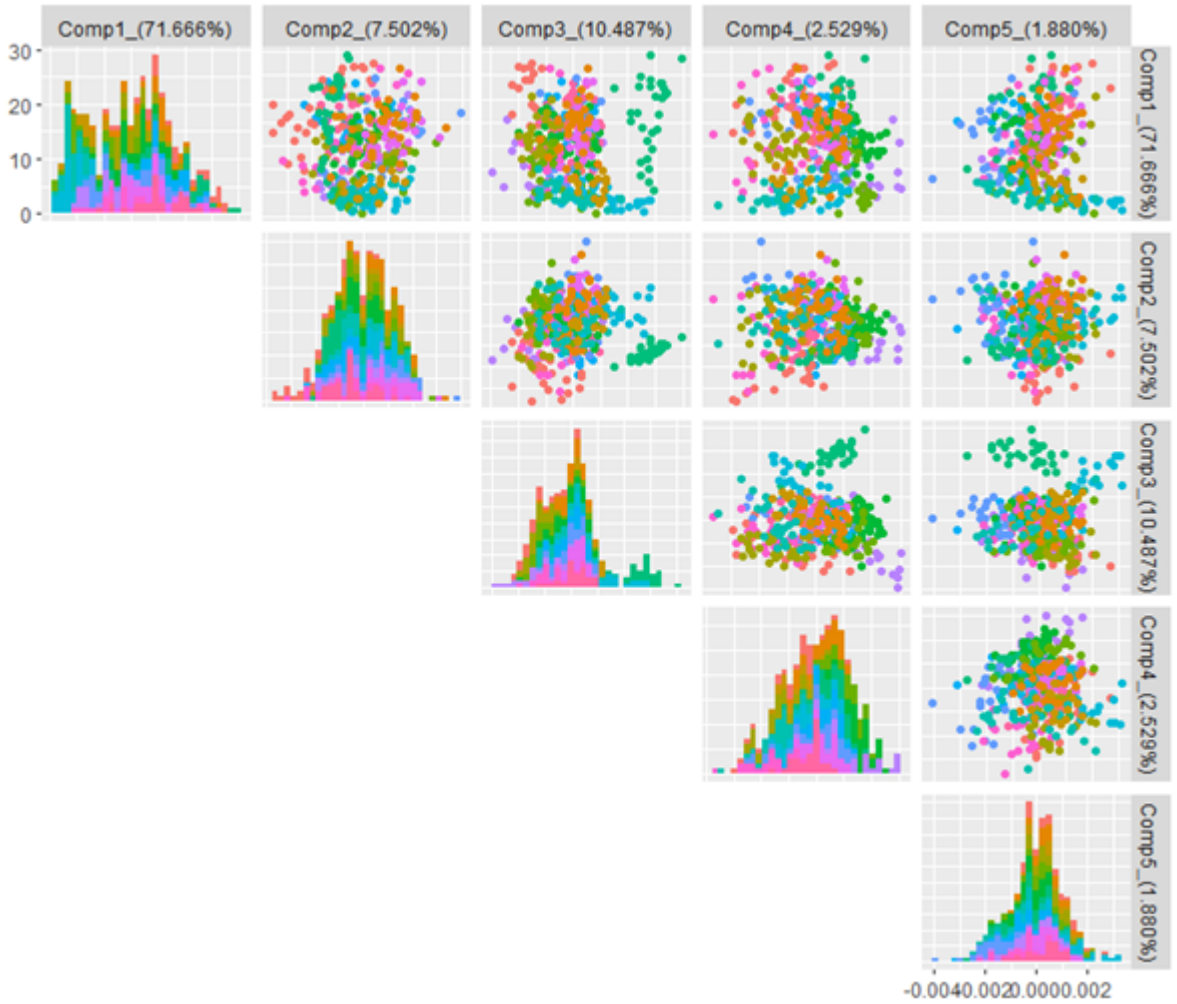
- Linear velocity estimation from commotion motion
- Active view planning for counting
- Motion planning for manipulators

Active Sensing for Counting

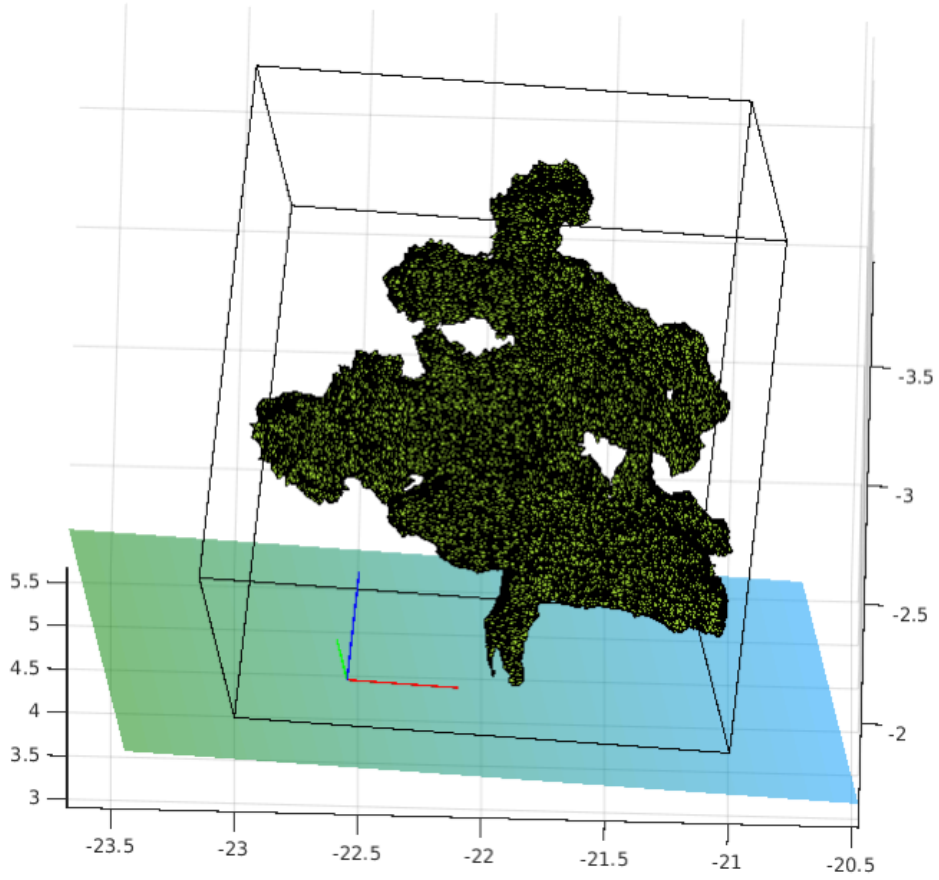
Roy and Isler, IROS 2017


Collection and Network Formation

From Here..



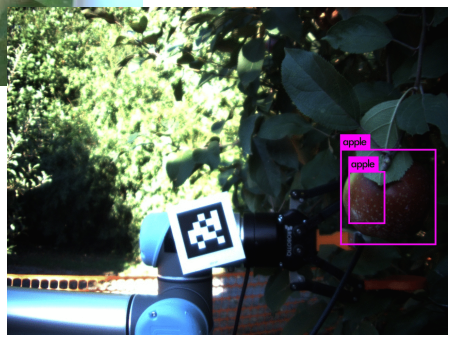
Anderson, Tong, Luby


5.5
5
4.5
4
3.5
3
-23.5
-23
-22.5
-22
-21.5
-21
-20.5
-3.5
-3
-2.5
-2

Development and Evaluation of an Autonomous Strawberry Harvesting Robot

Ya Xiong, Pal Johan From, Lars Grimstad, Norwegian University of Life Sciences, Norway
Cheng Peng, Volkan Isler, University of Minnesota, USA

Ai-Ping Hu, GTRI



Students

- Pravakar Roy, UMN, CS
- Konrad Ahlin, GA-Tech/GTRI, ME
- Josh Anderson, UMN, Hort
- Partial involvement/support
  - Nikolaos Stefas
  - Nicolai Haeni
  - Wenbo Dong
  - Crystal Luo

MIN-98-G02
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Thank you!

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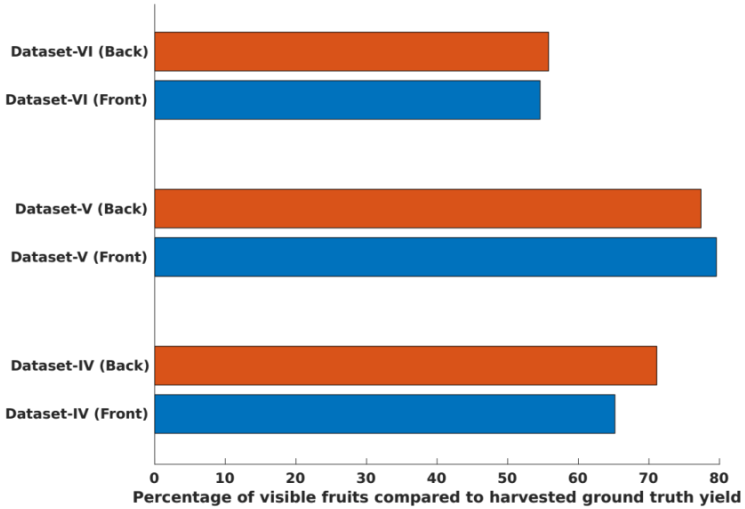
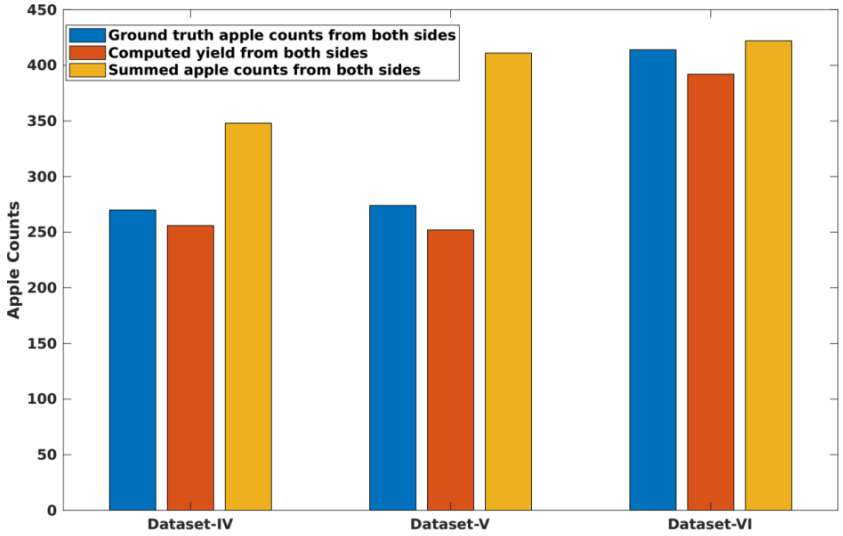
Yield Results



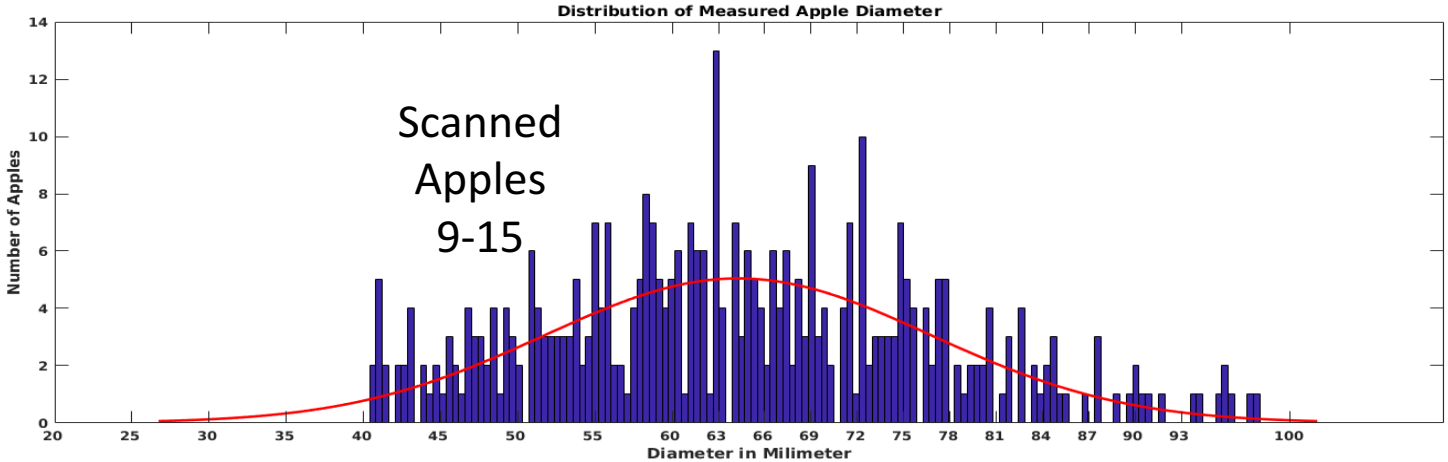
Fruits visible from a single side



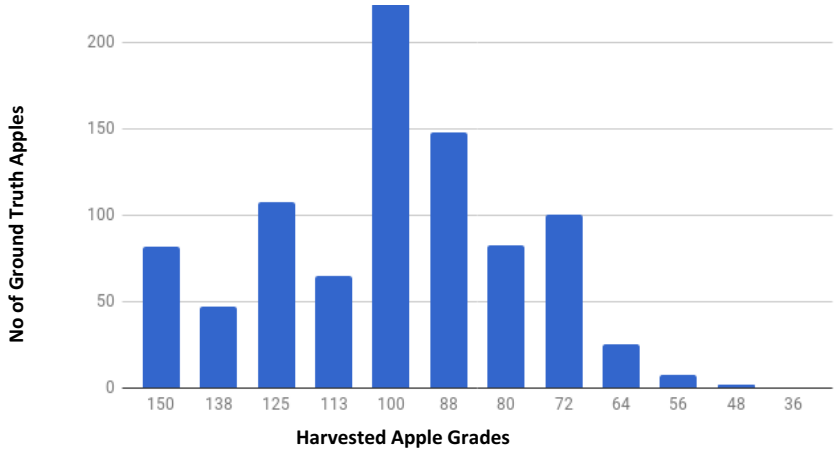
Yield Results

Datasets	Harvested fruit counts	Merged fruit counts from both sides	Sum of fruit counts from single sides
Dataset-IV	270	256 (94.81%)	348 (128.89%)
Dataset-V	274	252 (91.98%)	411 (150%)
Dataset-VI	414	392 (94.68%)	422 (101.93%)

Diameter Estimation Results



Measured
Apples
9-29



Grade	Diameter (mm)
150	66.55
138	68.072
125	69.85
113	72.13
100	74.42
88	77.47
72	81.026
64	83.56
56	86.36
48	88.9
36	92.20

[Washington Apple Size]